Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 3

17 May 2023

Zone A afternoon | Zone B morning | Zone C afternoon

Candidate session number

1 hour

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[35 marks]**.

Section A	Questions
Answer all questions.	1 – 3

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 12
Option C — Ecology and conservation	13 – 16
Option D — Human physiology	17 – 20

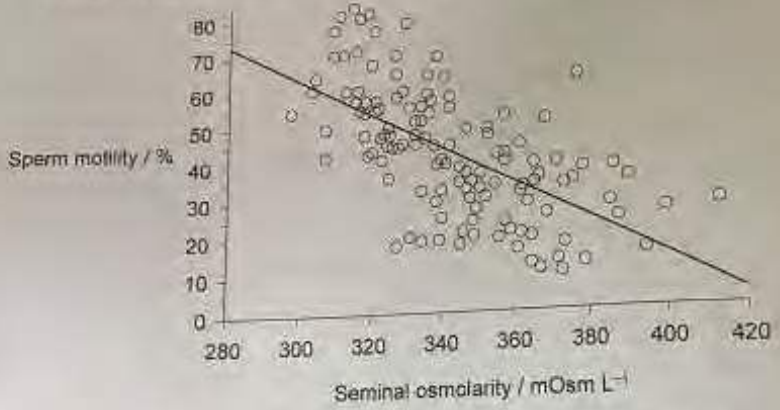
Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1 (a) Define osmolarity.

(1)

A study was done on the osmolarity of semen and sperm movement (motility).



(b) (i) State the relationship between osmolarity and sperm motility.

(1)

(ii) The same study showed that blood plasma has a lower osmolarity than semen. Explain how that would affect the movement of water between blood plasma and semen.

(2)

(This question continues on the following page)

(Question 1 continued)

The electron micrograph shows human sperm

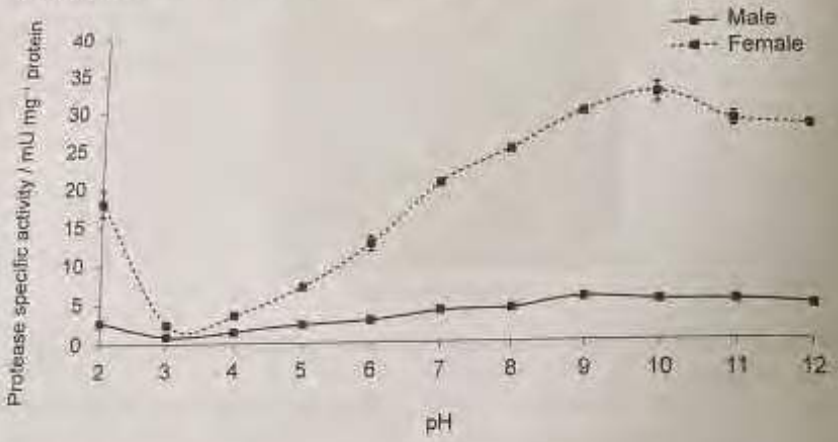
Magnification 6300x

(c) Calculate the actual length of the head of the sperm indicated by the arrow, showing your working [1]

(d) Explain a change that would take place in sperm placed in a hypotonic solution. [1]

2. (a) Outline the effect of low temperature on enzyme activity [1]

Guppies (*Poecilia reticulata*), popular aquarium fish, were used to test the effect of changes in pH on the activity of intestinal protease enzymes in each sex.



(b) Identify the independent and dependent variables in this study. [2]

Independent variable: .....

Dependent variable: .....

(c) Explain how change in pH affects the protease activity of the females. [2]

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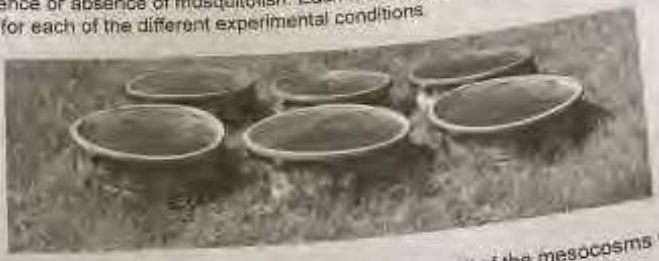
3. Mosquitofish (*Gambusia affinis*) are aquatic organisms that feed on mosquito larvae, other insects, zooplankton and detritus. Open mesocosms were established outdoors in 30 large water tanks designed to match natural aquatic habitats in California, USA.

Experiments were set up to measure the effect of extra nutrient availability on the community in the presence or absence of mosquitofish. Each tank was covered with netting. Six tanks were used for each of the different experimental conditions.



(a) State **one** variable that should have been the same in all of the mesocosms when they were set up. [1]

(b) Suggest **one** reason for using netting to cover the mesocosms. [1]

(c) Outline the advantage of having six replicates of each experimental condition. [1]

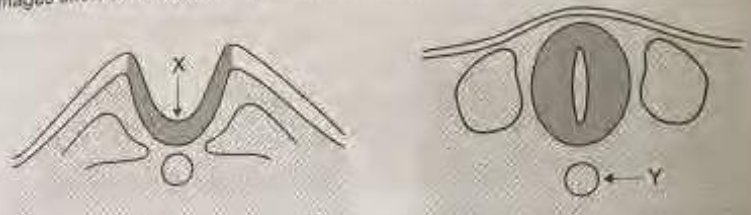
(d) Explain the advantages of using mesocosms instead of doing the experiment in the natural habitat. [2]

Section B

Answer **all** of the questions from **one** of the options. Answers must be written within the answer boxes provided.

Option A — Neurobiology and behaviour

4. The images show two stages of a process in the development of embryonic tissue in *Xenopus*.



(a) State the two structures indicated by X and Y on the images.

X: .....

Y: .....

The image shows one stage of early development of a neuron in an embryo.

(b) Outline one essential process that occurs during the development of neurons in an embryo.

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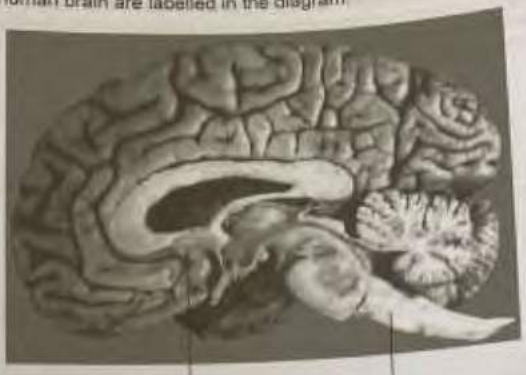
(Option A continues on the following page)

(Option A continued)

5. Two areas of the human brain are labelled in the diagram.



(a) Identify **one** function that is controlled by **each** area. [1]

(i) Nucleus accumbens:

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[1]

(ii) Medulla oblongata:

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(b) Explain how the brain may recover function after an accident or a stroke. [2]

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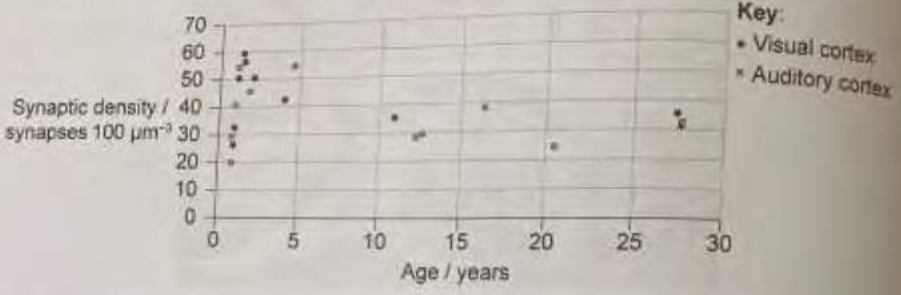
(Option A continues on the following page)

(Option A continued)

6. After the age of 30, the number of synapses in the various parts of the human brain remain relatively constant. An electron microscope was used to measure the number of synapses in the auditory cortex and visual cortex of brains after autopsies. The graph shows the mean synaptic density in the auditory cortex and visual cortex below the age of 30.



(a) The capacity to learn certain skills such as reading music and learning foreign languages is greater at an early age. Comment on this statement using the data shown in the graph. [2]

(b) Outline the process that reduces the number of synapses. [2]

(Option A continues on the following page)

(Option A, question 6 continued)

(c) State **one** method, other than autopsies, to identify the role of different brain parts. [1]

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7. Distinguish between the perception of colour in people with red-green colour-blindness and people with normal trichromatic vision. [2]

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(Option A continues on the following page)

(Option A continued)

8. The diagram shows the structures of the human ear.

(a) (i) State the part of the ear that detects movement of the head. [1]

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(ii) Identify the type of sensory receptor that detects movement of the head. [1]

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(Option A continues on the following page)

(Option A, question 8 continued)

(b) Explain the function of the cochlea in the perception of sound. [4]

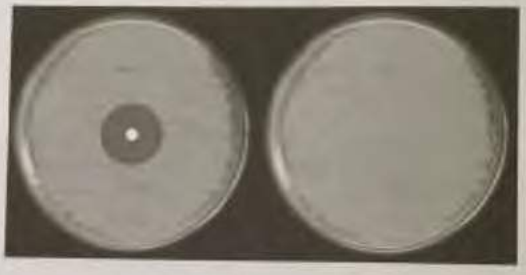
End of Option A

Option B — Biotechnology and bioinformatics

9. (a) (i) State the scientific name of the microorganism used commercially to produce citric acid. [1]

(ii) State one use of the citric acid produced. [1]

The image shows two petri dishes with bacteria growing on the surface of agar, one of them testing the effect of a certain substance as an inhibitor of the growth of the bacteria.



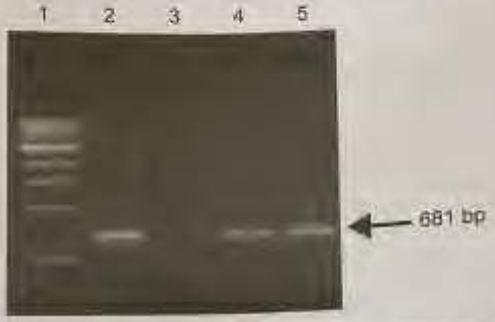
(b) Outline how the experiment is carried out. [3]

(Option B continues on the following page)

(Option B continued)

10. The surface antigen gene of hepatitis B virus (HBsAg) was cloned into plant cells using *Agrobacterium tumefaciens*. Plant cells were selected according to their resistance to kanamycin.

Transformed plant cells were analysed by PCR to see whether they contained the HBsAg gene of 681 base pairs (bp). The image shows the resulting electrophoretic gel with lane 1 showing the reference ladder (size markers), lane 2 a positive control and lane 3 a negative control. Lanes 4 and 5 show the PCR amplification of genomic DNA from transformed plant cells.



(a) Using the electrophoretic gel image, deduce with a reason whether the plant cell transformation was successful. [1]

(b) Explain the use of kanamycin in the selection of transformed plant cells. [3]

(Option B continues on the following page)

(Option B continued)

11. *Genetically modified, glyphosate-resistant soybeans have been used in agriculture for several decades.*

(a) *Outline one benefit of using genetically modified, glyphosate-resistant soybeans.* [1]

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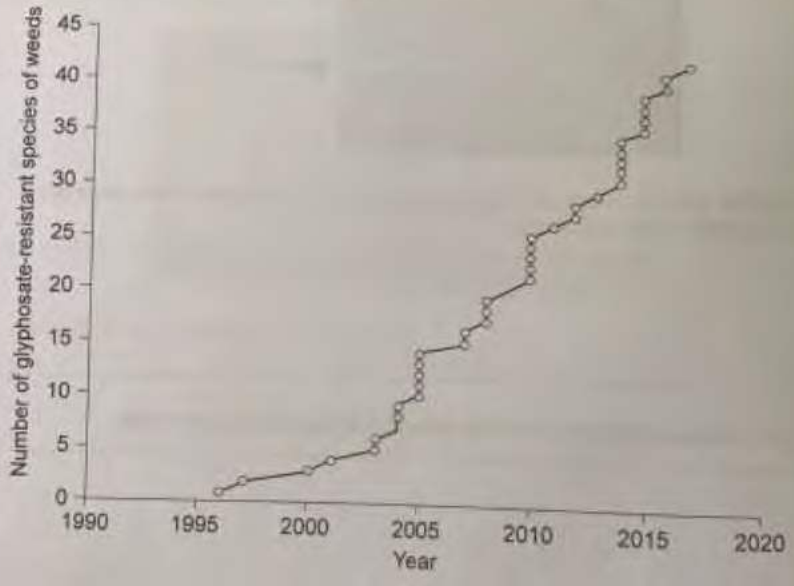
The graph shows the number of glyphosate-resistant weed species in the world over the past three decades.



(Option B continues on the following page)

(Option B, question 11 continued)

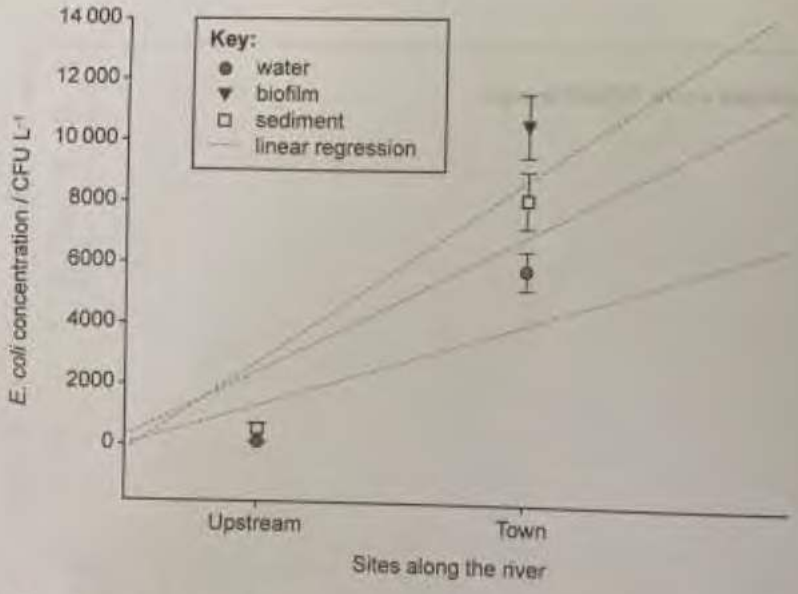
(b) The use of glyphosate-resistant crops has increased greatly in the world in the last decades. Comment on the environmental impact of using glyphosate-resistant crops. [3]

(Option B continues on the following page)

(Option B continued)

12. (a) Biofilms cause many environmental problems. State one of these problems. [1]

Samples were collected from water, sediment and biofilm scraped from rock surfaces at two sites along the Weihe River in China. For each sample, the concentration of *Escherichia coli*, a fecal coliform bacterium, was determined as the number of colony-forming units (CFU L^{-1}) from each sample.



(b) (i) Suggest a reason for the difference in concentration of *E. coli* between samples from the town and upstream. [1]

(Option B continues on the following page)

(Option B, question 12 continued)

(ii) Suggest a reason for the higher concentration of *E. coli* in biofilms in the town samples. [1]

(c) Describe how biofilms result in resistance to antimicrobial agents. [4]

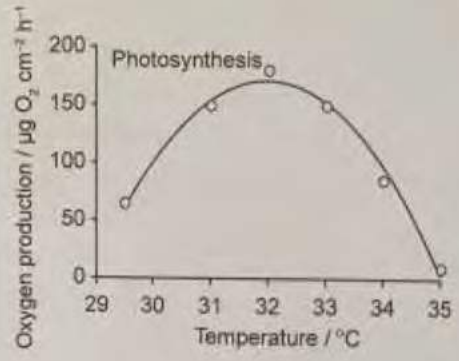
End of Option B

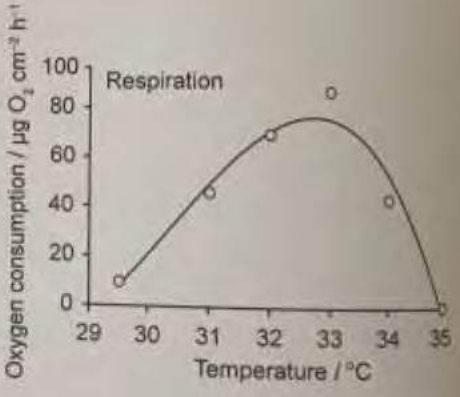
Option C — Ecology and conservation

13. A study was done on the effect of heat stress on species of coral and their relationship with zooxanthellae algae.

(a) Describe the relationship between these two types of organisms. [2]

(b) The graphs show the effects of heat stress on the rates of photosynthesis in zooxanthellae and respiration of both organisms.





(i) Distinguish between the temperatures at which heat stress begins to have an effect on the rates of the two processes. [1]

(Option C continues on the following page)

(Option C, question 13 continued)

(ii) Global warming increases sea temperatures. Coral bleaching occurs at sea water temperatures above 33 °C. Using the data in the graphs, explain the reasons for coral bleaching. [2]

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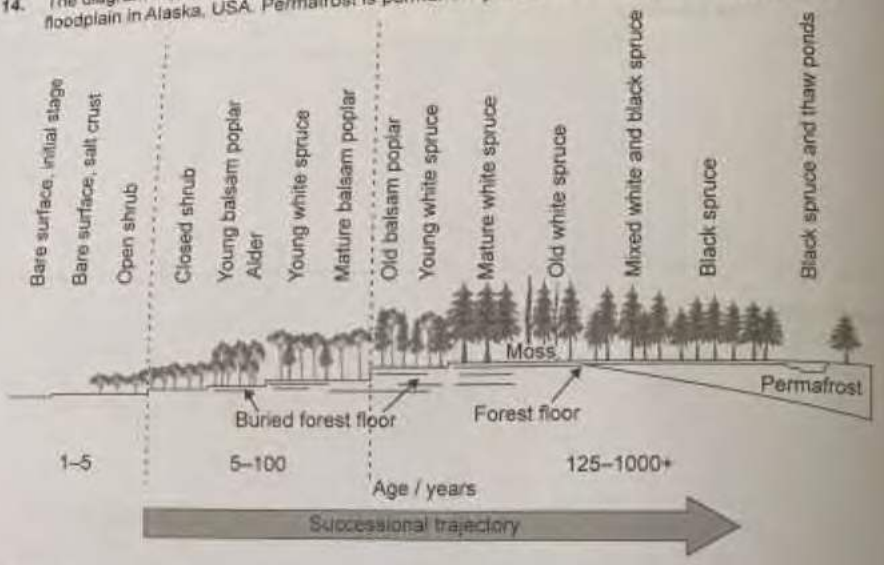
(Option C continues on the following page)

(Option C continued)

14. The diagram represents primary succession that occurs in an Arctic ecosystem, on a river floodplain in Alaska, USA. Permafrost is permanently frozen subsoil found in Arctic regions.



(a) Outline primary succession. [1]

(b) Describe two limiting factors on this ecosystem. [2]

(Option C continues on the following page)

(Option C, question 14 continued)

(c) Outline processes that must occur over time to produce deeper soil. [2]

15. Two small fields of the same size were sampled to determine the biodiversity of the wild plants found in them.

Plant species	Number of individuals	
	Field 1	Field 2
Daisy	170	306
Dandelion	170	170
Buttercup	170	34
Total	510	510
Simpson's reciprocal index of diversity	3.0	2.1

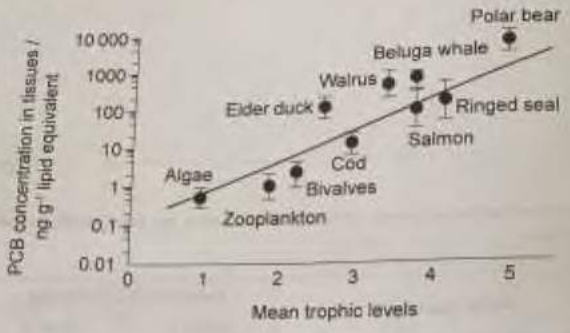
(a) Using the data in the table, compare the richness of the two fields. [1]

(b) The Simpson's reciprocal index of diversity for each field is shown in the table. Explain the significance of these values in terms of the ecosystem. [2]

(Option C continues on the following page)

(Option C continued)

16. The diagram shows the levels of PCBs, which are hydrophobic industrial waste pollutants, in a marine food web.



(a) (i) Suggest a reason that bivalves are classified between trophic levels 2 and 3 in this food web. [1]

(ii) Predict what could happen to the food web if polar bears were to become extinct. [1]

(Option C continues on the following page)

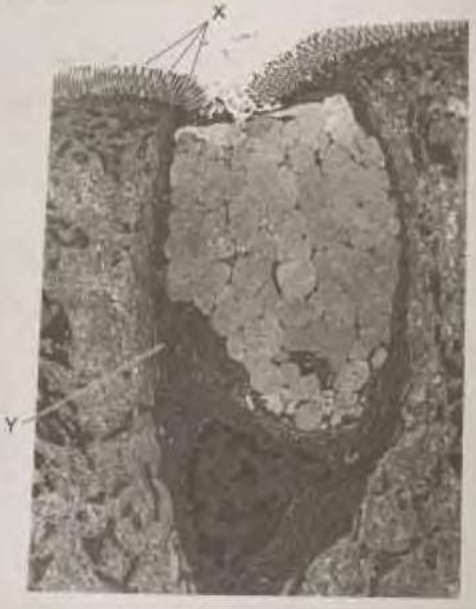
(Option C, question 16 continued)

(b) Explain how the levels of PCBs increase so greatly over the trophic levels. [4]

End of Option C

Option D — Human physiology

17. The electron micrograph shows cells in the wall of the small intestine.



Magnification 15 000 x

(a) (i) State the name of the structures marked X. [1]

(ii) Describe how the structures marked X help the cells in the intestinal wall to carry out their function. [1]

(Option D continues on the following page)

(Option D, question 17 continued)

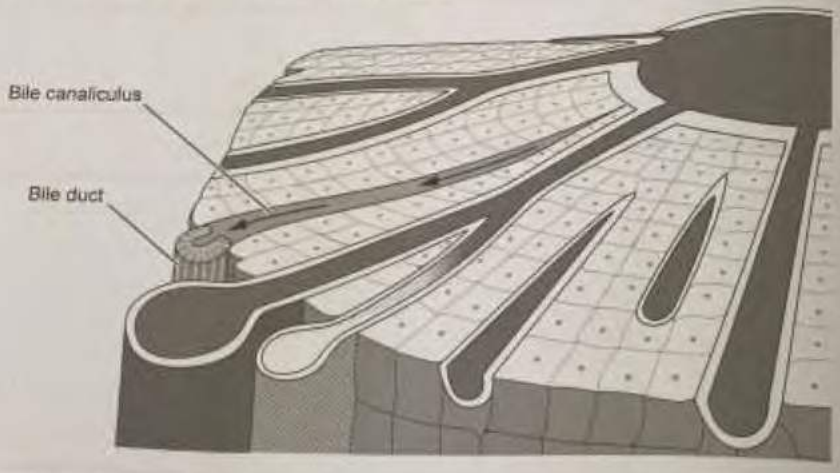
(iii) Identify with a reason the type of cell marked Y. [1]

(b) Describe the cause of stomach ulcers. [3]

(Option D continues on the following page)

(Option D continued)

18. The liver has a dual blood supply. The diagram shows some of the basic structures of liver tissue.

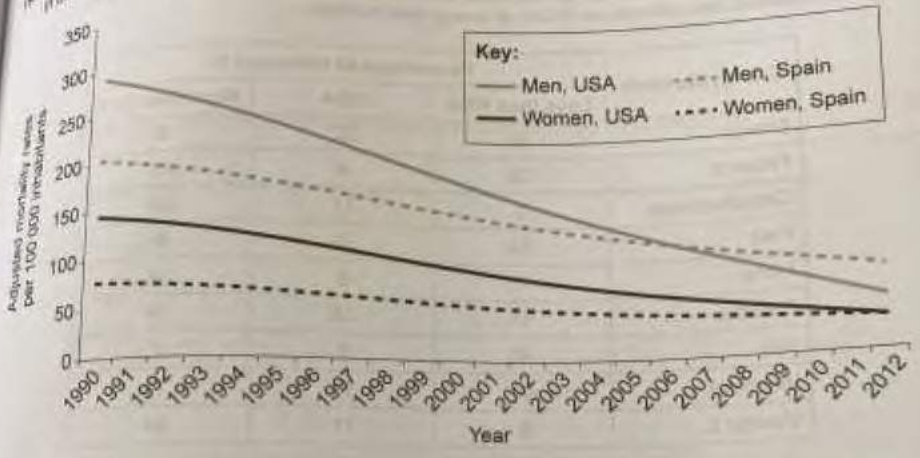


Describe the flow of blood through the liver. [3]

(Option D continues on the following page)

(Option D continued)

14. The graph compares the rates of mortality due to coronary heart disease in men and women in the USA and Spain.



(a) Compare and contrast the trends for men and women in the epidemiological data from both countries. [2]

(b) Suggest one reason for the trends shown over time in both countries. [1]

(Option D continues on the following page)

(Option D continued)

20. Children with congenital heart disease are usually malnourished and present some degree of functional and/or structural damage of organs. The table shows the percentage of children with congenital heart disease that are ingesting less, more or the recommended daily allowance (RDA) of energy and nutrients.

Energy/Nutrient	Percentage of children / %		
	Less than RDA	RDA	More than RDA
Energy	50	32	18
Proteins	29	8	63
Carbohydrates	0	71	29
Fats	53	39	8
Fibre	71	5	24
Calcium	11	13	76
Iron	90	5	5
Vitamin A	66	16	18
Vitamin C	5	11	84

(a) Predict with a reason the risk that a child with congenital heart disease might have

(i) scurvy. [1]

(ii) anemia. [1]

(b) State one effect of a low intake of fibre. [1]

(Option D continues on the following page)

(Option D, question 20 continued)

(c) Suggest **one** possible problem associated with a low fat intake. [1]

(d) Explain how the energy content of food can be determined by combustion. [4]

End of Option D

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1.c Parmegiani, L., 2012. *Human spermatozoa*. [image online] Available at: https://www.researchgate.net/figure/Human-Spermatozoa-magnification-6300-X_fig3_221928474 [Accessed 1 June 2020].

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4.b Boulan, B., Baghin, A., Ravanello, C., Deloulme, J.-C., Gory-Fauré, S., Andrieux, A., Brocard, J. and Denarier, E., 2020. [AutoNeurite]. *PLOS ONE* 15(7) [e-journal] Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0234529 [Accessed 1 April 2021]. REFERENCE REDACTED.

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